

METHOD AND APPARATUS FOR PERFORMING ANASTOMOSIS WITH EVERSION OF TISSUE EDGES AND JOINING OF EXPOSED INTIMA OF THE EVERTED TISSUE

[0001] This application claims the benefit of U.S. Provisional Application No. 60/152,001, filed on Sep. 1, 1999, and is a continuation-in-part of the pending U.S. patent application filed on Aug. 17, 2000, entitled "Apparatus and Method for Performing an Anastomosis, by Paul A. Spence, Warren P. Williamson, IV, George Christakis, Mark Ortiz, Craig B. Berky, Douglas P. Allen, Matthew J. Huddleston, Delbert T. Leimbach, Cecil R. Robinson, E. Dale VanHoose, Thomas J. Ward, and Marty J. Warnecke, which in turn claims the benefit of U.S. Provisional Application No. 60/150,033, filed on Aug. 20, 1999, U.S. patent application Ser. No. 09/200,796, filed on Nov. 27, 1998 (now pending), and U.S. patent application Ser. No. 08/714,615, filed on Sep. 16, 1996 (issued as U.S. Pat. No. 5,868,763).

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates to the art of surgery. More specifically, it relates to the field of apparatus and methods for performing anastomosis without hand-suturing.

BACKGROUND OF THE INVENTION

[0003] In the United States, many coronary artery bypass graft (CABG) procedures performed on patients annually. Each of these procedures may include one or more graft vessels which are hand sutured. Until recently, coronary artery bypass procedures have been performed with the patients on cardiopulmonary bypass while the heart is stopped with cardioplegia and the surgery is performed on an exposed, stationary heart.

[0004] The vast majority of CABG procedures performed currently are accomplished by opening the chest wall to gain access to the coronary vessels. Through the use of heart lung bypass machines and a drug to protect the heart muscle, the heart is stopped and remains still during the procedure. In this setting, the surgeon has ample time and access to the vessels to manipulate hand suturing instruments such as forceps, needle holders and retractors.

[0005] However, with increasing costs of hospital stays and increased awareness by patients of other minimally invasive surgical procedures interest in developing a minimally invasive CABG procedure is increasing hospitals need to reduce costs of procedures and patients would like less post-operative pain and speedier recovery times.

[0006] With an increased incentive to reduce costs, there is a renewed interest in redesigning cardiothoracic procedures. A few pioneering surgeons are now performing minimally invasive procedures whereby the coronary artery bypass is performed through a small incision in the chest wall. There are some surgeons that believe that the best way to perform a minimally invasive coronary artery bypass procedure is to perform the procedure on a beating heart, i.e., without heart-lung bypass and cardioplegia. This minimizes the time it takes to perform the procedure and reduces the cost of the operation by eliminating the heart lung bypass machine.

[0007] In the case of minimally invasive procedures on a beating heart, the surgeon starts by making a mini-thorac-

otomy between the fourth and fifth ribs and, sometimes, removing the sternal cartilage between the fourth or fifth rib and the sternum. The space between the fourth and fifth ribs is then spread to gain access to the internal mammary artery (IMA) which is dissected from the wall of the chest. After dissection, it is used as the blood supply graft to the left anterior descending artery of the heart (LAD). Below the IMA lies the pericardium and the heart. The pericardium is opened exposing the heart. At this point, the LAD may be dissected from the fissure of the heart and suspended up with soft ligatures to isolate the artery from the beating heart.

[0008] Typically, a special retractor gently applies pressure to the heart muscle to damp movement at the LAD. A small arteriotomy is performed in the LAD and the graft IMA is sutured to the LAD. Traditionally, to gain access to the cardiac vessels to perform this procedure the sternum is sewn in half and the chest wall is separated. Although this procedure is well perfected the patient suffers intense pain and a long recovery.

[0009] Until recently all bypass graft procedures have been performed by hand suturing the tiny vessels together with extremely fine sutures under magnification. The skills and instruments required to sew extremely thin fragile vessel walls together have been perfected over the last twenty years and are well known to the surgical community that performs these procedures.

[0010] FIG. 1 shows a conventional anastomosis using hand-sutures, in which coronary artery 10 and graft vessel 12 are connected in side-to-side fashion. One end (13) of vessel 12 is tied closed, and the side wall of vessel 12 near this closed end is to be attached to artery 10. The opposite end of vessel 12 (not shown) is to be attached to an aorta or IMA. In typical cardiopulmonary bypass procedures, one end of a graft vessel is grafted to a coronary artery (at a "distal" graft site) and the other end of the graft vessel is grafted to the aorta (at a "proximal" graft site). FIG. 1 shows a distal graft site. An incision 14 is made in artery 10 and a corresponding incision 16 is made in graft 12. The surgeon aligns the incisions and hand-sutures the aligned edges of the incisions together using sutures 18 and 20. Hand-suturing can also be used to perform an end-to-side anastomosis, in which an open end of the graft vessel is aligned with an incision in the sidewall of another vessel (e.g., an aorta) and the aligned tissue is hand-sutured together. The present invention can be used to perform either end-to-side or side-to-side anastomosis without hand-suturing.

[0011] There is a need (which is addressed by the present invention) for methods and apparatus useful for performing anastomosis during CABG surgery on a beating heart. When performing anastomosis during such surgery on a beating heart, use of hand-suturing to attach the graft vessel is very imprecise due to the translation of movement from the beating heart to the suspended artery. This motion may cause imprecise placement of the suture needles. Any imprecise placement of the sutures may cause a distortion of the anastomosis which may cause stenosis at this junction. The sutures used for this procedure are extremely fine (0.001" in diameter) and are placed less than 1 mm apart.

[0012] As one can imagine it is difficult enough to place suture needles the size of a small eyelash into a vessel wall with placement accuracy of better than 1 mm. To accomplish this feat of precision on a moving target is extremely